

§Appl. No. 09/851,432  
Amdt. dated April 16, 2004  
Reply to Office Action of, January 16, 2004

**REMARKS**

Applicant expresses his sincere appreciation for the allowance of claims 8, 12, 13, 16 and 17.

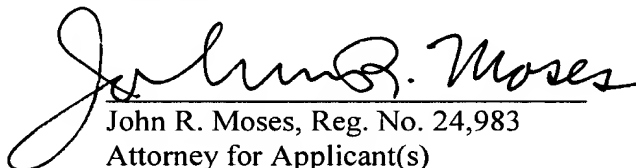
The drawings and specification have been amended to provide support for the "corrugated sheets" of claim 1. For the record, a translation of the German Priority Document is enclosed.

In that claim 16 has been cancelled and method claims 19-24 withdrawn from consideration, it is respectfully requested that this application now be passed to issue.

If there are any remaining issues which could be expedited by a telephone conference, the Examiner is courteously invited to telephone counsel at the number indicated below.

The Commissioner is hereby authorized to charge any fees associated with this response or credit any overpayment to Deposit Account No. 13-3402.

Respectfully submitted,

  
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**Attorney Docket No.: LINDE-566**

**Date: April 16, 2004**



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of

Jorg Dietrich

Serial No. : 09/851,432

Examiner: Tho V. Duong

Filed : May 9, 2001

Group Art Unit: 3743

Title : PLATE HEAT EXCHANGER

**STATEMENT**

**Mail Stop: AF**

Commissioner for Patents

P.O. Box 1450

Alexandria, VA 22313-1450

Sir:

**RECEIVED**

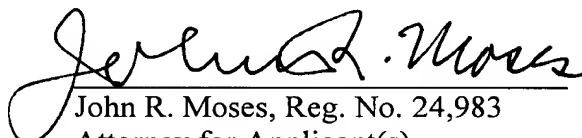
APR 20 2004

TECHNOLOGY CENTER R3700

The attached patent application is an English Translation of DE No.10022595.0, filed May 9, 2000.

The Commissioner is hereby authorized to charge any fees associated with this response or credit any overpayment to Deposit Account No. 13-3402.

Respectfully submitted,

  
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## PLATE HEAT EXCHANGER

This invention relates to a plate heat exchanger comprising a plurality of layers of at least partially corrugated sheet metal arranged parallel to one another, forming a plurality of heat-exchange passages, and at least one header that creates a flow connection among at least some of the heat-exchange passages.

Plate heat exchangers are built from several corrugated sheets (hereinafter referred to as "fins") that are stacked over one another and that are separated from one another in each case by flat metal partitions. The fins and partitions are connected tightly to one another in such a way that a heat-exchanger block is produced, thereby forming a plurality of heat-exchange passages for streams to be brought into heat exchange with one another. To introduce and withdraw the streams, headers with supports used for attaching the incoming or outgoing pipelines are mounted via the inlet or outlet openings of the heat-exchange passages.

All components of the plate heat exchangers are made from the same material, often from aluminum or aluminum alloys. Aluminum plate-fin heat exchangers are described in a brochure of Linde AG. Processing Engineering and Contracting Division entitled "Aluminum plate-fin heat exchangers". Descriptions of other plate heat exchangers are found in the literature, e.g. Chemical Engineers' Handbook, Perry & Chilton, 5th edition, McGraw-Hill, New York, 1973 pages 11-22 and 11-23.

The headers of the plate heat exchangers are often made of aluminum alloys having an increased strength compared to aluminum, but a relatively low strength compared to steel. At high pressures, therefore, only headers and supports with relatively small diameters can be used. To be able to heat or to cool large throughputs of mass under high pressure in aluminum heat exchangers, frequently several individual plate heat-exchanger blocks must be arranged in parallel. Even in the individual blocks under these conditions, double headers with several supports are, however, unavoidable. The design of aluminum plate heat exchangers is therefore very expensive in the case of certain flow criteria, especially under high pressures and at high flow rates.

An object of this invention is to provide an improved plate heat exchanger. Another object is to provide a novel header construction. Upon further study of the specification and appended claims, other objects of the invention will become apparent.

The objects are achieved according to the invention by a plate heat exchanger of the above-mentioned type, in which at least two parts of the plate heat exchanger comprise metallic materials that cannot be welded to one another on an industrial scale.

Consequently, the plate heat exchanger according to the invention are not limited to only one material, but rather require at least two different metallic materials. The two different materials can be adapted to the specific operational requirements of the individual components of the plate heat exchanger. Thus, for components that are exposed to an elevated compression stress, for example for the header of the heat exchanger, a metal is used that has a higher strength than the material used for the heat exchanger block.

The two parts of the heat exchanger that comprises different metals or different metal alloys are preferably bonded integrally together. Even at high stresses within the plate heat exchanger, the bond should provide a stable, durable and tight connection. By using fasteners which provide clamping or frictional connections, for example by screwing two components together, it is very difficult, owing to the different thermal coefficients of expansion, to connect the components tightly enough together so that the sealing of the flow paths in the plate heat exchanger is ensured permanently.

As mentioned above, it is often very difficult to provide a connection of different metallic materials that can withstand the thermal stresses of a heat exchanger. Fasteners which provide a clamping or frictional connection often are not satisfactory because of thermal expansion, and a more stable material is not possible partially because of the different properties of the metals that are involved. Thus, for example, aluminum and steel cannot be welded to one another at least on an industrial scale, and in the context of this invention such metals are considered non-weldable to each other.

It has therefore proven advantageous to provide an intermediate piece between the two components which piece comprises at least two different metals or metal alloys similar to the various metallic materials in the components that are to be connected to one another. The metals of the intermediate piece are selected in such a way that at least two surfaces of the

intermediate piece are present, which in each case can be connected to one of the two components in a tight and heat-resistant manner. Each component is preferably welded to one of the two sides of the intermediate piece which has the same type of metal.

The intermediate piece can be produced in various conventional ways while maintaining satisfactory bonding strengths. Individual metal layers of the intermediate piece can be applied, for example, by thermal coating. Preferably, the intermediate piece is produced by explosive plating of two or more metals. To this end, two or more metal plates are placed on one another and are provided with a layer of explosive substance. The pressures that are produced in an explosion bring the metals in the area of the boundary layer between two metal plates into the plastic state, by which a durable and tight connection is created.

The invention is suitable especially for plate heat exchangers in which the sheets or the entire heat exchanger blocks consist essentially of aluminum. To date, headers made of aluminum are also attached to such heat exchanger blocks, which are accompanied, however, by the above-mentioned strength problems. Headers made of steel, especially Cr-Ni steel, low-temperature steel or C-steel, are preferably used. The higher strength values of the steel headers allow larger header and support dimensions. The previously required double header with multiple supports or even the parallel arrangement of several plate heat exchangers is avoided or at least reduced. As a result, it is no longer necessary to have costly and difficult intermediate tubing between individual heat exchanger blocks.

Steel headers also provide additional cost advantages in the case of the tubing. For pipelines between different plate heat exchangers, which can now be made of steel instead of aluminum, smaller wall thicknesses in comparison to aluminum can now be provided owing to the higher strength of steel. The costs and the difficulty of the welding are significantly reduced. The steel pipelines from the plate heat exchangers that lead from or to the latter can be welded directly to the supports of the header and no longer must be connected to the latter via flange connections.

The headers are fastened to the heat exchanger block via an intermediate piece that comprises a composite material that preferably contains at least aluminum and steel.

The intermediate piece is excised from a plate of the composite material, which corresponds in size to approximately the contact surface between the header and the heat

exchanger block. One opposing side of the intermediate piece consists essentially of aluminum and the other opposing side consists essentially of steel. The intermediate piece is welded to the header on its steel side and then the thus prepared novel header construction is welded on the aluminum side to the heat exchanger block.

The intermediate piece provides for a slightly elevated position of the header, thereby making the weld more readily accessible and facilitating the welding. Moreover, the distance between two adjacent headers can be reduced, which results in a reduction in size of the heat exchanger block.

The heat exchanger according to the invention can be used in the temperature range of for example, between  $-270^{\circ}\text{C}$  and  $+200^{\circ}\text{C}$  and at an operating pressure of for example, from vacuum conditions to over 100 bar. In the entire range of use, the gas sealing property and stability of the heat exchanger are ensured.

The invention as well as other details of the invention are explained in more detail below based on the embodiments that are depicted in the drawings, wherein:

Figure 1 diagrammatically depicts the structure of a plate heat exchanger according to the invention, and

Figure 2 depicts the composite material in detail.

A heat exchanger block comprises a housing 1 containing corrugated and flat aluminum sheets conventionally soldered together in a soldering furnace. The heat-exchange passages formed between the sheets are closed to the outside by cover strips forming the housing. An area 2 is used as an intake opening to the heat-exchange passages. A header 3, which is provided with a connecting piece 4, creates a flow connection between the supply line for one of the fluids that is to undergo heat exchange, not shown, through the connecting piece 4, to the heat-exchange passages.

A frame 5 is welded to header 3, and the thus prepared header is then welded gastight to intake opening 2. Frame 5 is depicted more precisely in Figure 2. Frame 5 consists essentially of an aluminum layer 6 and a steel sheet 7, which are connected to one another using an explosive plating process. The thus produced plate heat exchange is distinguished by high strength and is preferably used in high-pressure applications.

Claims

1. Plate heat exchanger that consists of several pieces of sheet metal that are arranged parallel to one another, that are at least partially corrugated and that form a considerable number of heat-exchange passages, as well as at least one header that creates a flow connection among at least some of the heat-exchange passages, characterized in that at least two parts (1, 2, 3) of the plate heat exchanger consist of metallic materials that cannot be welded to one another.

2. Plate heat exchanger according to, wherein two parts (1, 2, 3) are connected integrally together.

3. Plate heat exchanger according to claim 2, wherein an intermediate piece (5) that consists of two different metals or metal alloys (6, 7) is found between the two parts.

4. Plate heat exchanger according to claim 3, wherein intermediate piece (5) is produced by explosive plating.

5. Plate heat exchanger according to one of claims 1 to 4, wherein sheets (2) consist of aluminum.

6. Plate heat exchanger according to one of claims 1 to 5, wherein header (3) consists of steel, especially Cr-Ni steel, low-temperature steel or C-steel.

7. Plate heat exchanger according to one of claims 3 to 6, wherein intermediate piece (5) contains aluminum and steel.

AbstractPlate Heat Exchanger

The invention relates to a plate heat exchanger that consists of several pieces of sheet metal that are arranged parallel to one another, that are at least partially corrugated and that form a considerable number of heat-exchange passages. A header creates a flow connection among at least some of the heat-exchange passages. At least two parts (1, 2, 3) of the plate heat exchanger consist of metallic materials that cannot be welded to one another. (Figure 1)



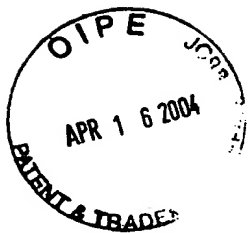


Figure 1

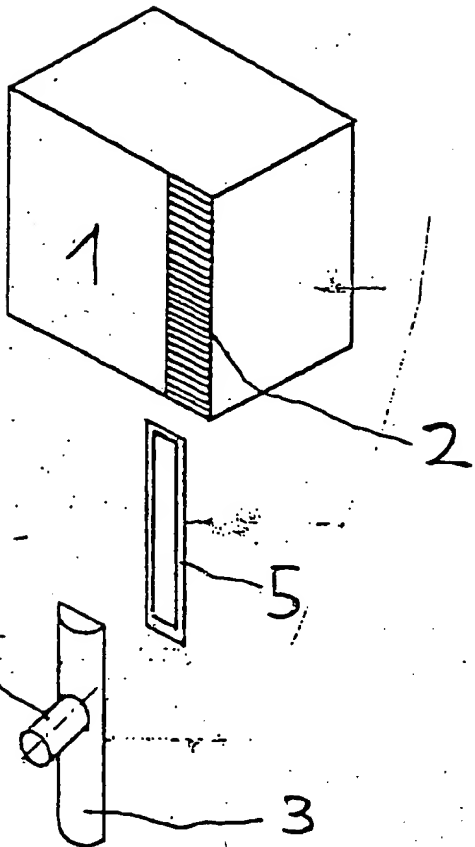


Figure 2

